


FORM PTO-1390 (REV 10-95)		U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER	
<b>TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. §371</b>				MERCK 2372	
				U.S. APPLICATION NO (If known, see 37 CFR §1.5) <b>10/048157</b>	
INTERNATIONAL APPLICATION NO PCT/EP00/06317		INTERNATIONAL FILING DATE 5 JULY 2000		PRIORITY DATE CLAIMED 29 JULY 1999	
TITLE OF INVENTION NITRATION IN A STATIC MICROMIXER					
APPLICANT(S) FOR DO/EO/US WURZIGER, Hanns, et al.					
<p>Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:</p> <ol style="list-style-type: none"> <li><input checked="" type="checkbox"/> This is a <b>FIRST</b> submission of items concerning a filing under 35 U.S.C. §371</li> <li><input type="checkbox"/> This is a <b>SECOND</b> or <b>SUBSEQUENT</b> submission of items concerning a filing under 35 U.S.C. §371.</li> <li><input type="checkbox"/> This express request to begin national examination procedures (35 U.S.C. §371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. §371(b) and PCT Articles 22 and 39(1).</li> <li><input checked="" type="checkbox"/> A proper Demand for International Preliminary Examination was made by the 19<sup>th</sup> month from the earliest claimed priority date.</li> <li><input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. §371(c)(2))             <ol style="list-style-type: none"> <li><input type="checkbox"/> is transmitted herewith (required only if not transmitted by the International Bureau).</li> <li><input checked="" type="checkbox"/> has been transmitted by the International Bureau.</li> <li><input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US).</li> </ol> </li> <li><input checked="" type="checkbox"/> A translation of the International Application into English (35 U.S.C. §371(c)(2)).</li> <li><input checked="" type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. §371(c)(3))             <ol style="list-style-type: none"> <li><input type="checkbox"/> are transmitted herewith (required only if not transmitted by the International Bureau).</li> <li><input type="checkbox"/> have been transmitted by the International Bureau.</li> <li><input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired</li> <li><input checked="" type="checkbox"/> have not been made and will not be made.</li> </ol> </li> <li><input type="checkbox"/> A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. §371(c)(3)).</li> <li><input type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. §371(c)(4))</li> <li><input type="checkbox"/> A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. §371(c)(5)).</li> </ol> <p>Items 11. to 16. below concern document(s) or information included:</p> <ol style="list-style-type: none"> <li><input type="checkbox"/> An Information Disclosure Statement under 37 C.F.R. §§1.97 and 1.98.</li> <li><input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. §§3.28 and 3.31 is included</li> <li><input checked="" type="checkbox"/> A <b>FIRST</b> preliminary amendment.             <input type="checkbox"/> A <b>SECOND</b> or <b>SUBSEQUENT</b> preliminary amendment.</li> <li><input type="checkbox"/> A substitute specification.</li> <li><input type="checkbox"/> A change of power of attorney and/or address letter.</li> <li><input type="checkbox"/> Other items or information:</li> </ol>					

U.S. APPLICATION NO. (if known, see 37 CFR §1.5) <b>10/048157</b>		INTERNATIONAL APPLICATION NO. PCT/EP00/06317		ATTORNEY'S DOCKET NUMBER MERCK 2372	
17. <input checked="" type="checkbox"/> The following fees are submitted:  <b>BASIC NATIONAL FEE ( 37 CFR §1.492 (a) (1) - (5)):</b>  Search Report has been prepared by the EPO or JPO..... \$890.00  International preliminary examination fee paid to USPTO (37 CFR §1.482) . . \$710.00  No international preliminary examination fee paid to USPTO (37 CFR §1.482) but international search fee paid to USPTO (37 CFR §1.445(a)(2))..... \$740.00  Neither international preliminary examination fee (37 CFR §1.482) nor international search fee (37 CFR §1.445(a)(2)) paid to USPTO .. . \$1040.00  International preliminary examination fee paid to USPTO (37 CFR §1.482) and all claims satisfied provisions of PCT Article 33(2)-(4). .... \$100.00  <b>ENTER APPROPRIATE BASIC FEE AMOUNT =</b>				<b>CALCULATIONS</b> <small>PTO USE ONLY</small>	
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 C.F.R. §1.492(e)).					
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	9 - 20 =	0	x \$ 18.00	\$0.00	
Independent claims	1 - 3 =	0	x \$ 84.00	\$0.00	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ \$ 280.00		
<b>TOTAL OF ABOVE CALCULATIONS =</b>				\$890.00	
Reduction of 1/2 for filing by small entity, if applicable. A Verified Small Entity Statement must also be					
<b>SUBTOTAL =</b>				\$890.00	
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 C.F.R. §1.492(f)).					
<b>TOTAL NATIONAL FEE =</b>				\$890.00	
Fee for recording the enclosed assignment (37 C.F.R. §1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. §§3.28, 3.31). \$40.00 per property					
<b>TOTAL FEES ENCLOSED =</b>				\$890.00	
				Amount to be refunded:	
				charged:	
a. <input checked="" type="checkbox"/> A check in the amount of <u>\$890.00</u> to cover the above fees is enclosed  b. <input type="checkbox"/> Please charge my Deposit Account No. <u>13-3402</u> in the amount of \$_____ to cover the above fees. A duplicate copy of this sheet is enclosed.  c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. <u>13-3402</u> . A duplicate copy of this sheet is enclosed.					
<b>NOTE: Where an appropriate time limit under 37 C.F.R. §§1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. §1.137(a) or (b)) must be filed and granted to restore the application to pending status.</b>					
SEND ALL CORRESPONDENCE TO: Customer Number 23,599					
 <b>23599</b> PATENT TRADEMARK OFFICE			SIGNATURE <u>Anthony J. Zelano</u> NAME <u>27,969</u> REGISTRATION NUMBER		
Filed: 29 JANUARY 2002 AJZ:kmo					

# APPLICATION DATA SHEET

## APPLICATION INFORMATION

Application Type::	REGULAR
Subject Matter::	UTILITY
CD-ROM or CD-R?::	NONE
Title::	NITRATION IN A STATIC MICROMIXER
Attorney Docket Number::	MERCK 2372

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#### CORRESPONDENCE INFORMATION

Correspondence Customer Number:: 23599

#### REPRESENTATIVE INFORMATION

Representative Customer Number:: 23599

#### DOMESTIC PRIORITY INFORMATION

Application::	Continuity Type::	Parent Application::	Parent Filing Date::
This Application	National Stage of	PCT/EP00/06317	07/05/00

#### FOREIGN PRIORITY INFORMATION

Application Number:	Country::	Filing Date::	Priority Claimed::
199 35 692.0	Germany	07/29/99	YES

#### ASSIGNMENT INFORMATION

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**IN THE UNITED STATES DESIGNATED/ELECTED OFFICE**

International Application No. : PCT/EP00/06317  
International Filing Date : 5 JULY 2000  
Priority Date(s) Claimed : 29 JULY 1999  
Applicant(s) (DO/EO/US) : WURZIGER, Hanns, et al.

Title: NITRATION IN A STATIC MICROMIXER

**PRELIMINARY AMENDMENT**

Commissioner for Patents  
Washington, D.C. 20231

SIR:

Prior to calculating the national fee, and prior to examination in the National Phase of the above-identified International application, please amend as follows:

**IN THE CLAIMS:**

3. (Amended) Process according to Claim 1, characterized in that the process is continuous.
4. (Amended) Process according to Claim 1, characterized in that
  - a) the aromatic or heteroaromatic compound is firstly derivatised,
  - b) the resultant derivative is dissolved in a solvent and
  - c) nitrated in a micromixer using a nitrating reagent, and
  - d) the nitrated product is isolated from the resultant solution.
5. (Amended) Process according to Claim 1, characterized in that the nitrated product is separated off from the reaction mixture by extraction with a solvent.

6. (Amended) Process according to Claim 1, characterized in that the reaction mixture flows through the microreactor at an adequate flow rate of from 1 $\mu$ l/min to 10ml/min, and the reaction is carried out at a temperature in the range from -40 to 150°C, with the course of the reaction being monitored by gas chromatography.

8. (Amended) Process according to Claim 4, characterized in that an aromatic or heteroaromatic compound is converted into a carbamate in a first reaction step.

9. (Amended) Process for the nitration of aromatic or heteroaromatic compounds selected from the group consisting of toluene, 1,2,3,4-tetrahydroisoquinoline, N-methoxycarbonyl-1,2,3,4-tetrahydroisoquinoline and benzofuran derivatives according Claim 1.

[illegible]

Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached pages are captioned **“Version With Markings to Show Changes Made”**.

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Filed: 29 January 2002



VERSION WITH MARKINGS TO SHOW CHANGES MADE

Claims 3 to 6, 8 and 9 were amended as follows:

3. (Amended) Process according to Claims 1 ~~and 2~~, characteriszed in that the process is continuous.
4. (Amended) Process according to Claims 1 ~~to 3~~, characteriszed in that
  - a) the aromatic or heteroaromatic compound is firstly derivatised,
  - b) the resultant derivative is dissolved in a solvent and
  - c) nitrated in a micromixer using a nitrating reagent, and
  - d) the nitrated product is isolated from the resultant solution.
5. (Amended) Process according to ~~one or more of~~ Claims 1 ~~to 4~~, characteriszed in that the nitrated product is separated off from the reaction mixture by extraction with a solvent.
6. (Amended) Process according to ~~one or more of~~ Claims 1 ~~to 5~~, characteriszed in that the reaction mixture flows through the microreactor at an adequate flow rate of from 1µl/min to 10ml/min, and the reaction is carried out at a temperature in the range from -40 to 150°C, with the course of the reaction being monitored by gas chromatography.
8. (Amended) Process according to Claims 4 ~~to 7~~, characteriszed in that an aromatic or heteroaromatic compound<sub>1</sub> is converted into a carbamate in a first reaction step.-
9. (Amended) Process for the nitration of aromatic or heteroaromatic compounds selected from the group consisting of toluene, 1,2,3,4-tetrahydroisoquinoline, N-methoxycarbonyl-1,2,3,4-tetrahydroisoquinoline and benzofuran derivatives according to ~~one or more of~~ Claims 1 ~~to 8~~.

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- 1 -

10/048157  
JC13 Rec'd PCT/PTO 29 JAN 2002

### Nitration in a static micromixer

5 The present invention relates to a novel process for the nitration of organic compounds, preferably of aromatic and heteroaromatic compounds, using nitrating reagents which are known from the literature and new types of nitrating reagents.

10 The nitration of organic substrates is a very important and frequently performed process in the chemical industry. Numerous publications relate to this subject.

15 Particular safety problems exist on performance of nitrations on an industrial scale, since firstly in some cases highly toxic chemical substances have to be used which, even considered alone, represent a considerable risk to the environment. Secondly, nitrations generally proceed in a highly exothermic manner, which means that there is an increased risk of explosion when carrying out these reactions.

20 There has hitherto been no lack of attempts to reduce these safety problems. However, as soon as large amounts of nitrated products are to be prepared and a scale-up is to be carried out, the above-mentioned safety problems come to the fore.

25 The object of the present invention was therefore to provide a novel process which is simple to carry out and an apparatus which enable nitrations of organic compounds, in particular of aromatic and heteroaromatic compounds, to be carried out in a simple, reproducible manner with increased safety, with reduced residual risk to the environment. A further object of the invention was to provide correspondingly nitrated products in increased yields and improved purities.

30 The object is achieved by a process for the nitration of aromatic or heteroaromatic compounds in which the aromatic or heteroaromatic compound in liquid form or in solution is mixed intensively and allowed to react with a liquid or dissolved nitrating reagent, selected from the group consisting of dilute nitric acid, 100% nitric acid, potassium nitrate in 100% sulfuric acid, mixtures  
35 of nitric acid and sulfuric acid ("nitrating acid"), nitric acid esters, mixtures of nitric acid with inorganic and organic anhydrides and dinitrogen pentoxide,

- 2 -

in a microreactor for an adequate residence time, and the desired nitration product is isolated from the resultant reaction mixture.

The microreactor used when carrying out the process is preferably a heatable flow reactor.

The object is furthermore achieved by a process which can be carried out continuously.

A particular variant of the process according to the invention consists in that

- a) the aromatic or heteroaromatic compound is firstly derivatised,
- b) the resultant derivative is dissolved in a solvent and
- c) nitrated in a micromixer using a nitrating reagent, and
- d) the nitrated product is isolated from the resultant solution.

The nitrated product is preferably separated off from the reaction mixture by extraction with a solvent, since this represents a simple form of work-up.

In accordance with the invention, the reaction mixture is pumped into the microreactor in such a way that it flows through the latter at a flow rate of at least 5 µl/min, and the reaction is carried out at a temperature in the range from -10 to 80°. At the same time, the course of the reaction is, if desired, monitored by gas chromatography. If desired, this can be carried out continuously.

If desired, the process according to the invention is carried out after the aromatic or heteroaromatic compound has been converted into a carbamate in a first reaction step.

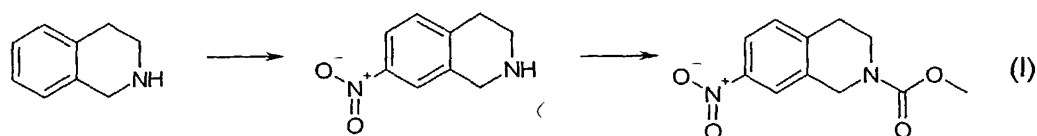
In particular, the process according to the invention is used for the nitration of compounds selected from the group consisting of toluene, 1,2,3,4-tetrahydroisoquinoline, N-methoxycarbonyl-1,2,3,4-tetrahydroisoquinoline and benzo-furan derivatives.

Various publications and patent applications disclose miniaturised flow reactors for organic reactions. Reactors of this type are preferably produced from thin silicon structures bonded to one another. Miniaturised reactors of this type have very narrow channels which, per se, tend to block very easily due to particles present or formed in the reaction solution.

The prerequisites for the ability to carry out a reaction in miniaturised flow reactors of this type therefore consist in that it can be carried out in the homogeneous liquid phase, and precipitations or the formation of particles during the reaction can be prevented.

In order to achieve the present object, numerous attempts to nitrate organic compounds, in particular aromatic and heteroaromatic compounds, have been carried out.

8-Nitro-N-methoxycarbonyltetrahydroisoquinoline, for example, is required as intermediate for the synthesis of chemical compounds used as active ingredients for the preparation of medicaments. This compound can be prepared by methods known from the literature, to be precise by nitration of 1,2,3,4-tetrahydroisoquinoline using potassium nitrate in concentrated sulfuric acid followed by acylation in accordance with the general reaction equation given below:



As part of the experimental programme mentioned above, it has been attempted to carry out this reaction with the aid of a microreactor. However, owing to the viscosity of 100% sulfuric acid, a considerable pressure built up in the micromixer and in the thin Teflon tubes. It has been found that this problem can be overcome with the aid of an injection pump operating at very low pump output.

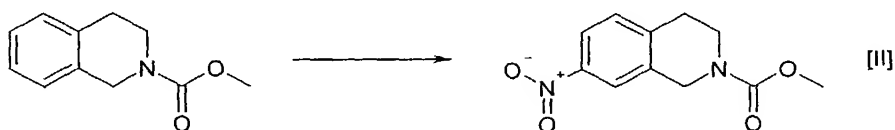
Subsequent experiments showed very efficient nitration results. When the reaction was complete, a liquid reaction mixture was obtained which had to be neutralised before the desired products were separated off.

However, since the aim was to provide a process which can be carried out simply and in an environmentally friendly manner, alternatives were sought.

Surprisingly, it has been found that an altered sequence of the synthesis enables this problem to be circumvented.

In a first step, 1,2,3,4-tetrahydroisoquinoline is converted into the corresponding carbamate. The carbamate is dissolved in a suitable solvent, such as, for example, dichloromethane, and nitrated at ambient temperature using 65% nitric acid.

Optimisation experiments have shown that this nitration can be carried out at a flow rate of 5  $\mu\text{l}/\text{min}$  in the microreactor with a good result, based on the ratio of starting compounds employed to product obtained. The nitration product obtained in this way can advantageously be isolated directly from the acidic reaction solution by extraction.



The process thus found for carrying out the desired reaction in a microreactor through which flow takes place is superior to a reaction in the stirred reactor usually used.

A very particular advantage is that, as soon as the performance parameters, such as temperature and flow rate, have been set and the system is in equilibrium, the reaction can be carried out continuously as long as there is a need for the desired reaction product. In addition, the product can be obtained in constant quality with stable yields. Correspondingly impressive results have been achieved, for example, in the nitration of N-methoxycarbonyl-1,2,3,4-tetrahydroisoquinoline in a continuous reaction, with the latter being maintained at equilibrium for the duration of six days.

The possibility of using the microreactor for further aromatic and heteroaromatic compounds has also been investigated. The nitration of toluene is described here in greater detail by way of example.

In a first series of experiments, toluene was mixed with an equivalent amount of dichloromethane and nitrated at various temperatures using 65% nitric acid. The ratio of the nitrated isomers to unreacted toluene is shown in the

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- 6 -

The nitrations described proceed with good to very good yields in the static micromixer. The selectivity can be influenced by varying various parameters, such as, for example, concentration, temperature (see Figure 2) or residence time.

The advantage of nitration in microfluid systems consists in better mass and heat transport, improved control of the reaction time and increased safety. The very small amounts of reagent present in the system are responsible for this.

This point is particularly important in the case of nitrations, which are generally highly exothermic, if, for example, the mixture consisting of 100% nitric acid and acetic anhydride, which reacts very selectively – the reactive species is the acetyl nitrate, which decomposes in an explosive manner at about 60°C – is employed.

A change in the residence time by variation of the pump output exhibited only a slight effect on the selectivity, or none at all, in this case. It can also be assumed that the activity of the nitrating reagents and the temperature have virtually no effect on the quantitative result of the reaction at a defined residence time.

This effect is significantly more pronounced if a mixture of toluene and acetic acid is treated with 100% nitric acid. In this case, the reacting reagent is acetyl nitrate, which is in some cases, depending on the species to be nitrated, regarded as a significantly more reactive, but also more selective nitrating reagent than nitric acid alone.

A mixture consisting of nitric acid and acetic anhydride or pre-distilled acetyl nitrate is a strong, but also hazardous reagent since it decomposes above 60°C.

By means of this reagent, it is even possible to nitrate heterocyclic compounds, which otherwise can only be nitrated with difficulty. For understandable reasons, however, this method normally only finds limited use.

- 7 -

In contrast to the situation in the industrial plants usually used for carrying out chemical reactions, firstly the temperature of the reaction mixture can be kept constant in each volume element in the micromixer systems according to the invention in accordance with the process according to the invention.

Secondly, only very small amounts of starting material are present in the apparatus at any point in time. This means that the nitration reactions described, which were hitherto only possible using special and expensive safety precautions, can be carried out readily in the present micromixer system.

The process according to the invention can be used in a simple manner for carrying out, for example, nitrations of toluene, 1,2,3,4-tetrahydroisoquinoline, N-methoxycarbonyl-1,2,3,4-tetrahydroisoquinoline and of benzofuran derivatives.

Suitable aromatic compounds are furthermore all monocyclic and polycyclic, homoaromatic or heteroaromatic compounds, as well as compounds which have a monocyclic or polycyclic, homoaromatic or heteroaromatic basic structure or partial structure, for example in the form of substituents.

Suitable aromatic compounds are, in particular:

benzene and derivatives thereof,

naphthalene and derivatives thereof,

azulene and derivatives thereof,

anthracene and derivatives thereof,

phenanthrene and derivatives thereof,

pyrene and derivatives thereof,

fluorene and derivatives thereof,

quinones, such as, for example, ortho- and para-benzoquinone, and

derivatives thereof, all naphthoquinones known to the person skilled in the art

and derivatives thereof, fluorenones, anthrones, phenanthrones, all known anthraquinones and derivatives thereof.

Heteroaromatic compounds which can be employed are the following:

oxygen-containing heteroaromatic systems (furans), such as, for example,

benzo-fused furans and derivatives thereof,



- 8 -

dibenzofurans and derivatives thereof,  
dibenzodioxanes and derivatives thereof,  
pyrylium cations and derivatives thereof,  
benzopyranones and derivatives thereof,  
5 nitrogen-containing heteroaromatic systems and derivatives thereof, such as,  
for example,  
  
pyrroles, pyrazoles, imidazoles, triazoles, tetrazoles, pyridines, pyrazines,  
10 pyrimidines, pyridinium salts, triazines, tetrazines, pyridine-N-oxide and  
derivatives thereof  
benzo-fused pyrroles (indoles, carbazoles, benzimidazoles and benzo-  
triazoles) and derivatives thereof,  
phenazine and derivatives thereof,  
15 quinolines and isoquinolines,  
chinnolines, quinazolines and quinoxalines,  
phenanthrolines and derivatives thereof,  
bipyridyls and higher homologues,  
acridines, acridones and derivatives thereof,  
20 pyrene and derivatives thereof,  
  
suitable sulfur-containing heteroaromatic systems and derivatives thereof are,  
for example,  
  
thiophenes and derivatives thereof,  
25 benzo-fused thiophenes (benzothiophenes and dibenzothiophenes) and  
derivatives thereof.

It is also possible to employ acenaphthylene, thiazoles, isothiazoles,  
biphenylenes, purines, benzothiadiazoles, oxazoles and isooxazoles in the  
30 process according to the invention.

Suitable solvents for these nitrations are the following:

- dilute and concentrated acids, such as, for example, sulfuric acid, nitric acid,  
35 acetic acid and trifluoroacetic acid



adequate residence time of the reaction mixture for the reaction in the reactor is ensured.

Basic prerequisites for the suitability of microreactors in the nitration process according to the invention are furthermore:

- the possibility of uniform temperatures in each volume element of the reactor,
- leak-proof and reliable connection means for supply and discharge lines for liquids, but where appropriate also for further equipment for reaction monitoring or for analytical purposes,
- leak-proof connection of the individual parts or structures forming the microreactor, both internally and to the outside, so that the liquid-carrying channels are separate from one another and the liquid cannot escape to the outside,
- easy handling in the event of faults.

For better understanding and in order to illustrate the present invention, examples are given below which are within the scope of protection of the present invention, but are not suitable for restricting the invention to these examples. The term "within the scope of the present invention" is also taken to mean, as already stated above, nitrations carried out using static miniaturised flow reactors which are likewise known to the person skilled in the art, but where the flow reactors used can allow larger flow rates for the preparation of larger amounts of product in the same time unit, and further both uniform temperatures and homogeneous mixing are ensured in each volume element of the reactor.

## Examples

### Example 1

1 g of 1,2,3,4-tetrahydroisoquinoline was carefully dissolved in 5 ml of concentrated sulfuric acid. The nitric acid was prepared by dissolving 1 g of potassium nitrate in 5 ml of concentrated sulfuric acid. Two 2 ml disposable plastic syringes were filled with the two solutions and attached to a Harvard Apparatus pump 22. The disposable syringes themselves were connected to a static silicon mixer, which was in turn

- 11 -

connected to a thin Teflon tube having a diameter of 0.25 mm and a length of 80 cm. The reaction was carried out at ambient temperature at a flow rate of 5 µl/min. The reaction mixture formed was collected in a vessel filled with ice pieces and neutralised using 2N NaOH before the product formed was extracted with dichloromethane.

1 g of 1,2,3,4-tetrahydroisoquinoline, dissolved in 5 ml of dichloromethane, was nitrated as described above at ambient temperature using 65% nitric acid and a flow rate of 5 µl/min. The work-up of the organic phase was carried out without prior neutralisation.

The same conditions were set for a continuous experiment, which was carried out continuously over six days. In this case, two syringes each with a capacity of 50 ml were used.

## Example 2

A disposable plastic syringe having a capacity of 2 ml was filled with a 1:1 mixture consisting of toluene and dichloromethane. A second syringe was filled with 65% nitric acid. These two syringes were connected, and a flow rate of 5 µl/min was set. Under these conditions, the reaction was carried out at 0, 20 and 30°C.

The course of the reaction was monitored and recorded using a Merck Hitachi HPLC instrument (L 6200 pump, variable wavelength UV detector and D 2500 chromatogram integrator). The separating column used was a Merck Lichrocart® RP Select B 250/4.

Solvent:

Mixture of 70% of acetonitrile and 30% of water, mixed with 1% of trifluoroacetic acid

Flow rate: 0.6 ml/min

Detector wavelength: 215 nm.

The nitrations of toluene were monitored with the aid of a Hewlett-Packard 6890 series GC system with an HP 5973 mass selection detector.

- 12 -

In order to carry out the experiments with 100% nitric acid, one syringe was filled with nitric acid and the other with pure toluene. The nitrations were carried out at 0, 21, 40, 60 and 80°C.

5 In order to carry out the experiments with acetyl nitrate, one syringe was filled with a 1:1 mixture consisting of toluene and acetic anhydride and another was filled with 100% nitric acid. The contents of the two syringes were pumped simultaneously into two different inlet channels of a micromixer for intensive mixing and nitration. The nitrations were  
10 carried out at -10, 0, 21, 40 and 60°C, with the course of the reaction being monitored as described above.

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## PATENT CLAIMS

1. Process for the nitration of aromatic or heteroaromatic compounds,  
characterised in that the aromatic or heteroaromatic compound in liquid  
5 form or in solution is mixed intensively and allowed to react with a liquid or  
dissolved nitrating reagent, selected from the group consisting of dilute  
nitric acid, 100% nitric acid, potassium nitrate in 100% sulfuric acid,  
mixtures of nitric acid and sulfuric acid ("nitrating acid"), nitric acid esters,  
mixtures of nitric acid with inorganic and organic anhydrides and dinitrogen  
10 pentoxide,  
in a microreactor for an adequate residence time, and the desired nitration  
product is isolated from the resultant reaction mixture.
2. Process according to Claim 1, characterised in that the microreactor used  
15 is a heatable flow reactor.
3. Process according to Claims 1 and 2, characterised in that the process is  
continuous.
4. Process according to Claims 1 to 3, characterised in that  
20 a) the aromatic or heteroaromatic compound is firstly derivatised,  
b) the resultant derivative is dissolved in a solvent and  
c) nitrated in a micromixer using a nitrating reagent, and  
d) the nitrated product is isolated from the resultant solution.
- 25 5. Process according to one or more of Claims 1 to 4, characterised in that  
the nitrated product is separated off from the reaction mixture by extraction  
with a solvent.
6. Process according to one or more of Claims 1 to 5, characterised in that  
30 the reaction mixture flows through the microreactor at an adequate flow  
rate of from 1 µl/min to 10 ml/min, and the reaction is carried out at a  
temperature in the range from -40 to 150°C, with the course of the reaction  
being monitored by gas chromatography.
- 35 7. Process according to Claim 6, characterised in that the reaction mixture  
flows through the microreactor at a flow rate of from 5 µl/min to 1 ml/min,  
and the reaction is carried out at a temperature in the range from -10 to

80°C, with the course of the reaction being monitored, if desired, continuously, by gas chromatography.

- 5 8. Process according to Claims 4 to 7, characterised in that an aromatic or heteroaromatic compound is converted into a carbamate in a first reaction step.
- 10 9. Process for the nitration of aromatic or heteroaromatic compounds selected from the group consisting of toluene, 1,2,3,4-tetrahydroisoquinoline, N-methoxycarbonyl-1,2,3,4-tetrahydroisoquinoline and benzofuran derivatives according to one or more of Claims 1 to 8.

## ABSTRACT

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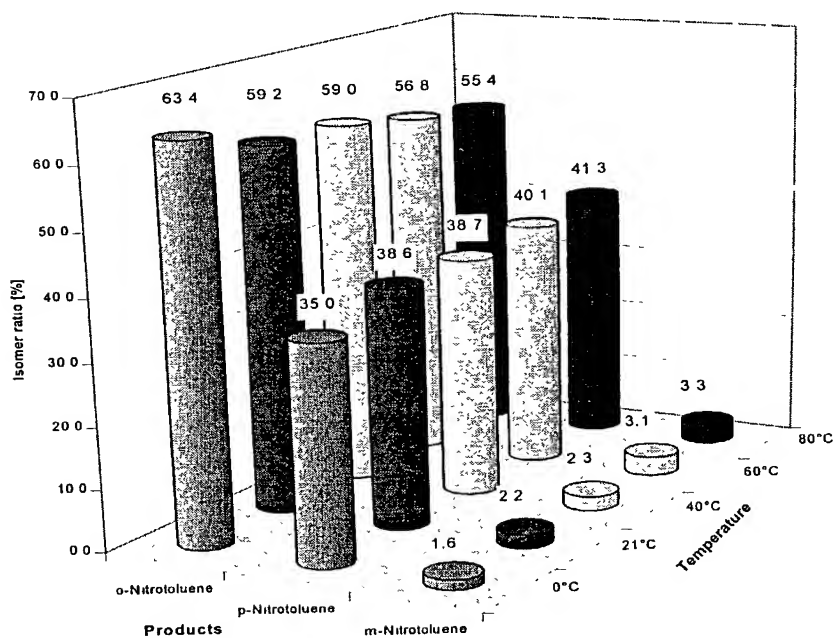
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- 16 -

Figure 1

Influence of temperature on the nitration of toluene  
(100% HNO<sub>3</sub> 10 µl/min)

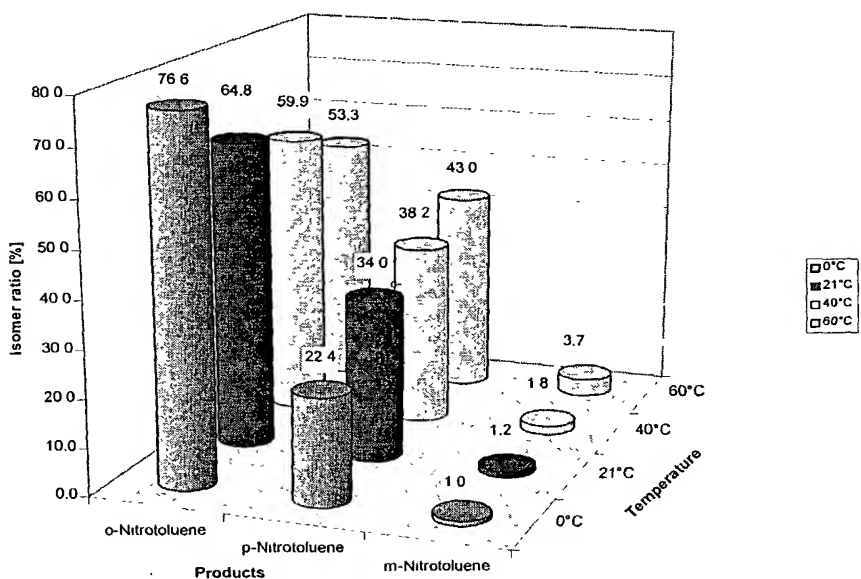


- 17 -



Figure 2

Influence of temperature on the nitration of toluene  
(acetyl nitrate, 20  $\mu\text{l}/\text{min}$ )



**COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY**  
(Includes Reference to PCT International Applications)ATTORNEY'S DOCKET  
NUMBER

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

**NITRATION IN A STATIC MICROMIXER**

the specification of which (check only one item below):

- ☐ is attached hereto.
- ☐ was filed as United States application  
Serial No. 10/048,157  
on \_\_\_\_\_  
and was amended  
on \_\_\_\_\_ (if applicable).
- ☒ was filed as PCT international application  
Number PCT/EP00/06317  
on 05.07.2000,  
and was amended under PCT Article 19  
on \_\_\_\_\_ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby claim priority benefits under Title 35, United States Code, § 119 or 365 (b) of the following United States provisional application(s) and of any foreign application(s) for patent or inventor's certificate or 365(a) of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

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COUNTRY (if PCT, indicate "PCT")	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 USC 119
Germany	199 35 692.0	07/29/99	<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO

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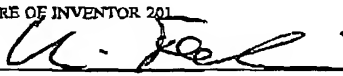
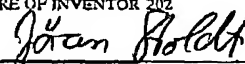
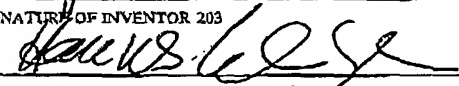
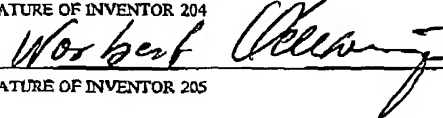
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SIGNATURE OF INVENTOR 201 	DATE 23.08.2002	SIGNATURE OF INVENTOR 207	DATE
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SIGNATURE OF INVENTOR 204 	DATE 23.08.2002	SIGNATURE OF INVENTOR 210	DATE
SIGNATURE OF INVENTOR 205	DATE	SIGNATURE OF INVENTOR 211	DATE
SIGNATURE OF INVENTOR 206	DATE	SIGNATURE OF INVENTOR 212	DATE